Check List 9(1): 028–033, 2013
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ISSN 1809-127X (available at *www.checklist.org.br*)

Check List
Journal of species lists and distribution

LISTS OF SPECIES

The fish fauna of streams from the upper rio Tocantins basin, Goiás State, Brazil

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ABSTRACT: This study aimed to provide a list of fish species from tributaries of rio das Almas and rio Maranhão basins, in the upper rio Tocantins basin, Goiás State, Brazil. For this study 21 stream stretches were sampled during the dry season in July 2010. A total of 2,279 individuals of 67 species, 19 families and five orders were collected. The most representative families in number of species were Characidae, Loricariidae, and Crenuchidae respectively. The genus *Knodus*, *Hypostomus* and *Characidium* showed the greatest abundance and distribution among the samplings. *Poecilia reticulata* was considered the only non-native species. The presence of a large number of endemic and undescribed species or with undefined taxonomic situation, in addition to the rapid habitat loss in this region, juts the need for the development of further studies in this basin.

INTRODUCTION

Brazil has the highest diversity of freshwater species of fishes in the world, with high species richness and endemism in many groups. This great biodiversity is related to large river systems, composed of basins and regions with very different ecosystem characteristics (Buckup *et al.* 2003; Abell *et al.* 2008; Lévêque *et al.* 2008).

The rio Tocantins-Araguaia basin is one of the most important hydrographic region of Brazil, with a drainage area of approximately 767.000 km^2 (Mérona *et al.* 2010). The rio Tocantins drains an approximated area of 343,000 km^2; it rises in the central region of Brazil in the Goiás State, and flows from South to North for about 2.750 km. The rio Tocantins ends in the Amazon delta in the Bay of Marajó, near the city of Belém, Pará State (Santos *et al.* 2004). The altitude varies from 100 m above the sea level in the lower course of the river to 1.000 m in the high region of the basin (Santos *et al.* 2004). The ichthyofauna of the rio Tocantins basin is closely related to the Amazon basin, especially in the lower course (Goulding *et al.* 2003), but the rio Tocantins basin is remarkable by containing both a high degree of endemism and high diversity (Santos *et al.* 2004; Hubert and Renno 2006; Lucinda *et al.* 2007; Abell *et al*. 2008; Bertaco and Carvalho 2010; Carvalho *et al.* 2010; Bertaco *et al.* 2011).

As a result of human actions the ichthyofauna of streams in this basin is suffering strong pressure, mainly by the expansion of agricultural frontiers, construction of dams, mining and introduction of exotic species (Ferreira and Tokarski 2007). These environmental problems resulting from uncontrolled human occupation make necessary urgent studies of local ichthyofauna. Thus, this work is aimed to provide a list of fish species of the rio das Almas and rio Maranhão basins, in the upper rio Tocantins basin, Goiás State, Brazil.

MATERIALS AND METHODS

Study area

The present study was made in the tributaries of rio das Almas and rio Maranhão basins, in the upper rio Tocantins basin (considered from its source in the Planalto of Goiás to the confluence with the rio Paranã) (Figure 1). The rio Maranhão rises in the ecological station of the Águas Emendadas in the Planalto Central, between the Goiás State and Distrito Federal; and rio das Almas rises in the Serra dos Pirineus State Park, in the municipality of Pirenópolis, Goiás State (Oliveira and Bispo 2001; Lima *et al*. 2007). The climate in this region is humid subtropical characterized by dry winter and hot summer (cwa). The average annual temperature is 21-25°C and the average annual rainfall is 1.500 mm, with 80% occurring between October and April (Ferreira and Tokarski 2007).

The study was performed in July 2010, twenty one sites were sampled in rio das Almas basins (municipality of Pirenópolis) and rio Maranhão basins (municipalities of Barro Alto and Goianésia) (Table 1). The collections were made using standard ichthyological gear, including sieves, seine nets and throw nets, aiming to capture a representative number of individuals in each sample unit. The sampling effort was of 60 minutes at each site. The collected fish were fixed in formalin solution 10% and after 48 h transferred to ethanol 70% solution. Species were identified using available literature, keys and help of specialists. The taxonomic classification follows Reis *et al*. (2003). Voucher specimens were deposited in the fish collection of the Museu de Zoologia da Universidade Estadual de Londrina, Londrina, (MZUEL), Paraná State, Brazil. Collects were authorized by IBAMA (collecting permit number 12120-1).

Data Analysis

To assess the inventory efficiency the richness extrapolation estimators Chao 1 (Chao 1987) and ACE (Abundance-based Coverage Estimator, Lee and Chao

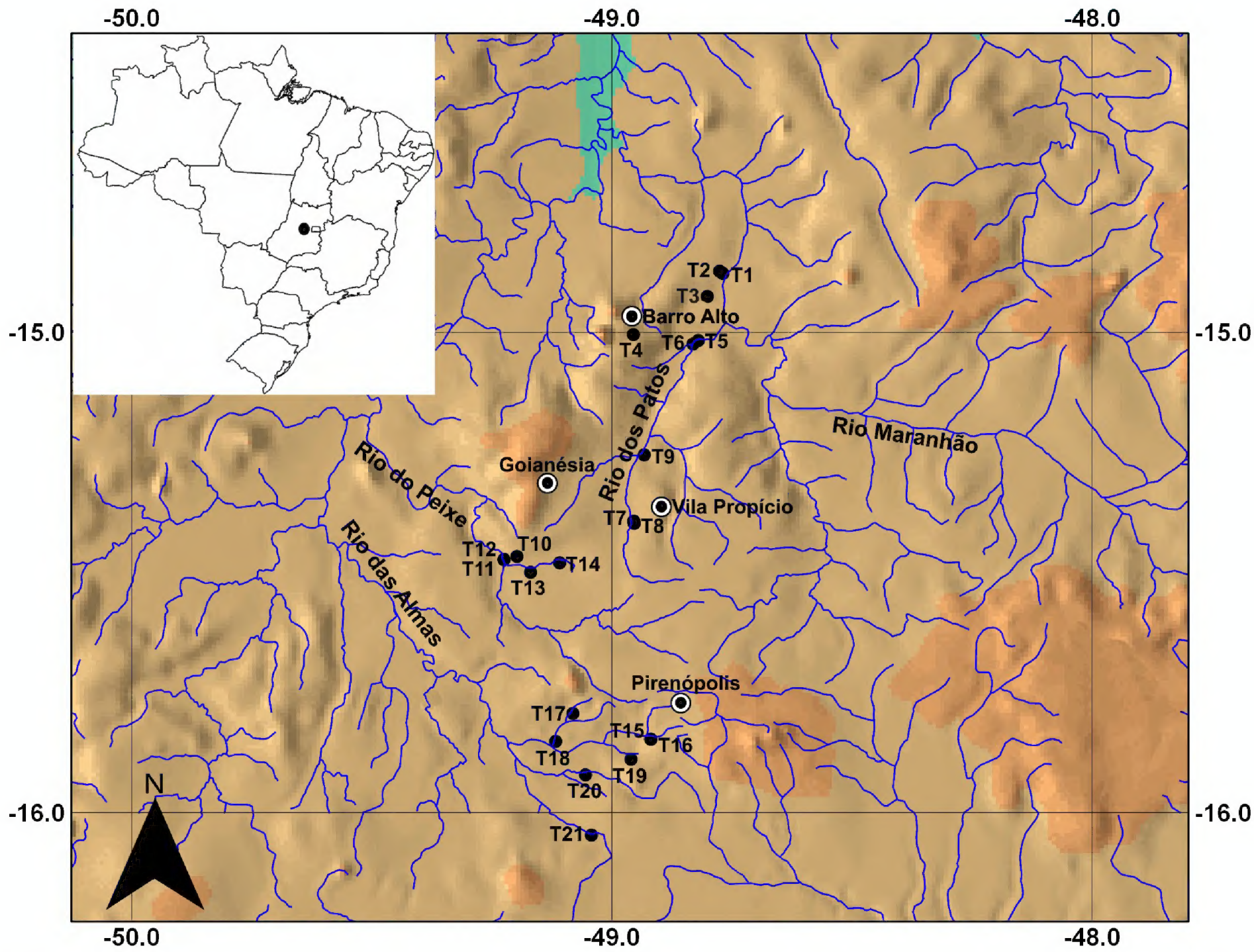

Figure 1. Map of the study area showing the collecting sites in the upper rio Tocantins basin, Goiás State, Brazil (based on Quantum Gis Sofware). Rio dos Patos (T1), ribeirão Chico Correia (T2), córrego Anilado (T3), córrego Pedra de Fogo (T4), rio dos Patos (T5), ribeirão Pouso Alegre (T6), córrego da Sola (T7), rio dos Patos (T8), rio dos Patos (T9), ribeirão das Lajes (T10), foz do ribeirão das Lajes (T11), rio dos Peixes (T12), ribeirão Chumbada (T13), rio da Santa Família (T14), rio das Almas - região alta (T15), ribeirão Barriguinha (T16), ribeirão Conceição (T17), córrego Santa Rita (T18), ribeirão Tapiocanga (T19), rio das Pedras (T20) and ribeirão Pau d'Água (T21).

Table 1. Geographical coordinates, altitude (Alt), types of mesohabitats (Meso.; riffles (Ri), run (Ru), pool (Po), waterfall (Wf), backwater (Bw)) and main substrate (Sub.; sand (Sa), gravel (Gr), rocks (Ro), Pebble (Pb), litter (Li), logs (Lo) and silt (Si)) from the collecting sites in the upper rio Tocantins basin, Goiás State, Brazil. Rib. = Ribeirão; Córr. = Córrego.

SITE	WATERCOURSES	LATITUDE (S)	LONGITUDE (W)	ALT (M)	MESO.	SUB.
T 1	rio dos Patos	14°52'37"	48°46'7"	503	Ri, Ru, Bw	Sa, Pb
T 2	rib. Chico Correia	14°52'21"	48°46'31"	532	Ri, Bw	Sa, Pb, Li
T 3	córr. Anilado	14°55'3"	48°48'4"	545	Bw, Po	Si, Li
T 4	córr. Pedra de Fogo	15°00'16"	48°57'18"	610	Ru, Po	Sa, Si, Gr
T 5	rio dos Patos	15°01'2"	48°49'12"	526	Ru, Bw	Sa, Si
T 6	rib. Pouso Alegre	15°01'26"	48°49'51"	535	Ri, Ru	Sa, Gr, Pb, Li
T 7	córr. da Sola	15°23'34"	48°57'15"	593	Ri, Bw, Po	Si, Pb, Li, Lo
T 8	rio dos Patos	15°23'51"	48°57'12"	605	Bw	Sa, Si, Li, Lo
T 9	rio dos Patos	15°15'17"	48°55'57"	604	Ri, Bw	Sa, Gr, Li, Lo
T 10	rib. das Lajes	15°27'59"	49°11'51"	584	Ru, Bw	Sa, Li, Lo
T 11	rib. das Lajes	15°28'21"	49°13'28"	583	Ru, Bw	Sa, Si, Li
T 12	rio dos Peixes	15°28'23"	49°13'28"	583	Ri, Bw	Sa, Gr, Pb
T 13	rib. Chumbada	15°29'58"	49°10'9"	615	Ru, Bw	Sa, Si
T 14	rio Santa Família	15°28'47"	49°06'31"	650	Ri, Bw, Po	Sa, Si, Pb, Lo
T 15	rio das Almas (alta)	15°50'49"	48°55'7"	749	Ri, Bw, Wf	Sa, Gr, Pb
T 16	rib. Barriguinha	15°50'49"	48°55'7"	764	Ri, Bw, Wf	Sa, Si, Gr, Pb
T 17	rib. Conceição	15°47'36"	49°04'51"	757	Ri, Ru, Bw	Sa, Gr, Li
T 18	córr. Santa Rita	15°51'6"	49°07'1"	659	Ri, Bw	Sa, Gr, Li, Lo
T 19	rib. Tapiocanga	15°53'20"	48°57'36"	707	Ru, Bw	Sa, Si, Li, Lo
T 20	rio das Pedras	15°55'17"	49°03'17"	619	Ru, Bw	Sa, Gr, Lo
T 21	rib. Pau d'Água	16°02'48"	49°02'33"	630	Ru, Bw, Po	Sa, Si, Li, Lo

1994) were used; and a species accumulation curve was generated (Figure 2), expressed by the number of individuals sampled to assess the efficiency of fish sampling methodology (Chao 2005). The program EstimateS 8.2 (Cowell 2009) was used for the calculations.

Results and Discussion

A total of 2.279 individuals representing 67 species belonging to 19 families and five orders were collected (Table 2). About of total number of species registered in this study, 46 were collected in the rio Maranhão sub basin, and 51 species in the rio das Almas sub basin. 30 species were common for the two sub basins. On the other hand, 15 exclusive species were present in the rio maranhão sub basin, and 21 in the rio das Almas sub basin.

The predominant orders were Characiformes (36 spp.) and Siluriformes (21 spp.), representing 53.7% and 31.4%, respectively of the total fish species captured. The families with higher species richness were Characidae (31.4%), followed by Loricariidae (17.9%), Crenuchidae (7.4%), Heptapteridae (5.9%) and Cichlidae (5.9%). The species with largest number of individual were *Knodus* cf. *chapadae* (24.1%), *Harttia punctata* (7.4%) and *Characidium zebra* (7.2%). The predominance of the families Characidae and Loricariidae of the orders Characiformes and Siluriformes is consistent with the general pattern found by other authors for the Neotropical region (Castro and Menezes 1998; Britski *et al*. 1999; Lowe-Mc Connell 1999; Shibatta *et al.* 2002; Reis *et al*. 2003; Buckup *et al.* 2007). Although species accumulation curve does not present a tendency to stabilize, the richness estimators Chao1 (75 ± 6 species) and ACE (76 ± 2 species) demonstrate good sampling efficiency.

The genus *Knodus* (*Knodus* cf. *chapadae, Knodus* sp.1 and *Knodus* sp.2) showed the greatest abundance and distribution in the collections, and can be an example of success in these environments. Some authors as Ortaz (2001), studying the feeding habit of *Knodus deuterodonoides* and *Knodus* sp., and Ceneviva-Bastos and Casatti (2007) to *Knodus moenkhausii*, considered these species as generalists and opportunists in the use of food resources; and according to Ceneviva-Bastos and Casatti (2007) these abilities may be reflected in the abundance and distribution of species once they can allocate energy to reproduction, becoming dominant in those environments.

Other important genera were *Characidium* and *Hypostomus*, by both the number of species (five and four species respectively) and a larger distribution and abundance. This result may be related to the preference of these species for habitats with strong rapids and rocks substrate where they can feed on insects, larvae and algae that are associated with these environments. Morphological adaptations as fusiform body, pectoral and pelvic fins enlarged and ventrally positioned in the body, beside adaptations in the mouth and lips in the case of *Hypostomus*, can help these species to adhere to the substrate and resist the flow of the current (Watson and Balon 1984; Matthews 1998; Aranha *et al*. 2000).

Two species considered as threatened of extinction were registered, *Mylesinus paucisquamatus* and *Brycon nattereri*. *Mylesinus paucisquamatus* is an endemic specie of the rio Tocantins basin, already *B. nattereri* is also found in the rio Paraná and rio São Francisco basins. The damming that alters the hydrologic cycle, destruction of riparian forests, and water pollution are among the main threats to these species (Lima *et al*. 2008; Machado *et al.* 2008).

The non-native species *P. reticulata* was recorded; this species is native from northwestern South America and Central America (Reis *et al.* 2003). The presence of *P. reticulata* can be an indicator of environmental degradation (Casatti *et al*. 2006), because it is an opportunistic species with high adaptive capacity and tolerance to variations in different habitat types (Kennard *et al.* 2005; Vieira and Shibatta 2007). In the localities where it was collected, this species may compete directly with native species for food or space. However, we believe that this species may have been assimilated as an additional component of the local diversity. In the stretches where it was sampled a high diversity of other species was also found, in contrast with the conjecture that *P. reticulata* can only be found in environments with low water quality where other species are unable to endure (Araújo *et al.* 2003). This species was found in five of the 21 sampled stretches, where the corrégo Lajes (T10) reached the highest abundance, which can be indicative of its establishment.

The information presented in this study can be important for the understanding, management and conservation of fish species in the upper rio Tocantins basin. The large number of endemic (23.8% of species) and undescribed species or with undefined taxonomic situation (43% of species), in addition to the rapid habitat loss in this region by agriculture, mining, livestick, dams and deforestation; make necessary the development of further studies for a better knowledge of the ichthyofauna of the upper rio Tocantins basin.

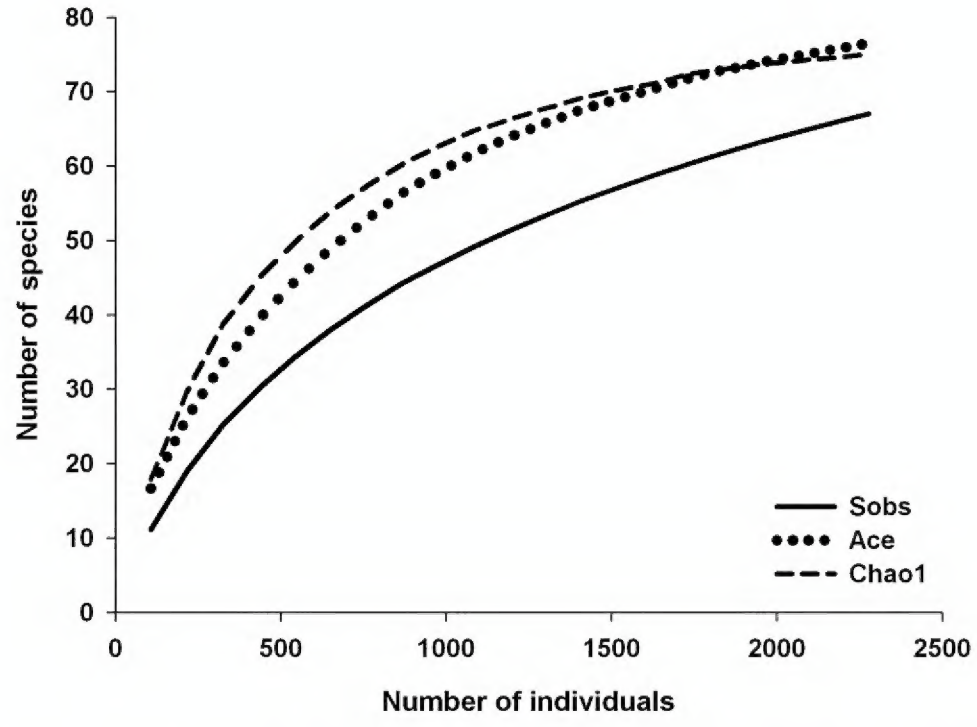

Figure 2. Species accumulation curve (Sobs) and the richness extrapolation estimators Chao 1 and ACE, for collections made in the upper rio Tocantins basin.

Table 2. List of fish species collected from the upper rio Tocantins basin, Goiás State, Brazil.

TAXA	SAMPLING SITES																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
CHARACIFORMES																					
Parodontidae																					
Apareiodon machrisi Travassos, 1957				X	X								X	X	X	X	X	X	X	X	X
Curimatidae																					
Cyphocharax spilurus (Günther, 1864)								X													
Cyphocharax cf. *vanderi* (Britski, 1980)														X							
Steindachnerina amazonica (Steindachner, 1911)								X			X										X
Anostomidae																					
Hypomasticus megalepis (Günther, 1863)																	X	X			
Leporinus friderici (Bloch, 1794)								X				X									
Crenuchidae																					
Characidium gomesi Travassos, 1956															X						
Characidium sp. 1																		X			
Characidium sp. 2																		X			
Characidium cf. *xanthopterum* Silveira, Langeani, da Graça, Pavanelli and Buckup, 2008	X					X								X							
Characidium zebra Eigenmann, 1909	X	X		X	X	X		X		X		X	X	X	X	X	X	X	X	X	X
Characidae																					
Astyanax cf. *bimaculatus* (Linnaeus, 1758)			X	X						X			X	X			X			X	
Astyanax elachylepis Bertaco and Lucinda, 2005		X						X													X
Astyanax sp. gr. *scabripinnis* (Jenyns, 1842)																X					
Astyanax sp.			X	X															X		X
Brycon nattereri Günther, 1864														X							
Bryconops caudomaculatus (Günther, 1864)											X			X			X	X			
Caiapobrycon tucurui Malabarba and Vari, 2000	X																	X			
Compsura sp.							X														
Creagrutus atrisignum Myers, 1927					X								X	X					X	X	
Creagrutus britskii Vari and Harold, 2001		X											X					X		X	
Ctenobrycon spilurus (Valenciennes, 1850)						X					X										
Galeocharax gulo (Cope, 1870)																				X	
Jupiaba apenima Zanata, 1997	X									X					X						X
Knodus cf. *chapadae* (Fowler, 1906)		X	X	X		X	X			X	X		X	X		X	X		X		
Knodus sp. 1	X									X					X		X				X
Knodus sp. 2											X	X	X		X	X		X	X	X	
Moenkhausia grandisquamis (Müller and Troschel, 1845)													X								
Moenkhausia aurantia Bertaco, Jerep and Carvalho, 2011		X	X							X	X		X	X						X	
Mylesinus paucisquamatus Jégu and Santos, 1988								X												X	
Myloplus sp.								X													
Phenacogaster sp.					X																
Ctenocheirodon pristis Malabarba and Jerep, 2012																					X
Serrapinnus sp.		X				X															
Acestrorhynchidae																					
Acestrorhynchus falcatus (Bloch, 1794)								X										X			
Erythrinidae																					
Hoplias malabaricus (Bloch, 1794)				X		X										X					
SILURIFORMES																					
Cetopsidae																					
Cetopsis arcana Vari, Ferraris and de Pinna, 2005							X											X			
Callichthyidae																					
Aspidoras eurycephalus Nijssen and Isbrücker, 1976																			X		
Trychomycteridae																					
Paravandellia sp.																				X	
Loricariidae																					
Ancistrus sp.				X											X	X	X	X	X	X	X
Corumbataia cf. *tocantinensis* Britski, 1997				X						X		X			X	X			X		
Harttia punctata Rapp Py-Daniel and Oliveira, 2001								X				X			X		X	X	X	X	X
Hypostomus sp. 1								X													
Hypostomus sp. 2					X				X												

TABLE 2. ***CONTINUED.***

TAXA	SAMPLING SITES																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Hypostomus sp. 3					X																
Hypostomus sp. 4	X	X		X					X	X		X	X			X	X	X	X	X	X
Hypostomus sp. 5	X		X		X			X													X
Parotocinclus sp.					X					X											
Rineloricaria sp.										X	X		X	X	X	X		X	X	X	X
Spatuloricaria cf. *evansii* (Boulenger, 1892)								X				X						X			X
Squaliforma emarginata (Valenciennes, 1840)									X												
Pseudopimelodidae																					
Microglanis sp. n.						X															
Pseudopimelodus pulcher (Boulenger, 1887)												X									
Heptapteridae																					
Cetopsorhamdia molinae Miles, 1943												X						X			
Phenacorhamdia sp.	X			X						X	X	X	X		X				X	X	X
Pimelodella sp.										X					X			X	X	X	
Rhamdia quelen (Quoy and Gaimard, 1824)															X	X					
GYMNOTIFORMES																					
Gymnotidae																					
Gymnotus sp.	X				X																
Sternopygidae																					
Eigenmannia trilineata López and Castello, 1966						X	X													X	
Sternopygus macrurus (Bloch and Schneider, 1801)							X														
Apteronotidae																					
Apteronotus camposdapazi Santana and Lehmann A., 2006						X															
Apteronotus sp.						X															
CYPRINODONTIFORMES																					
Poecillidae																					
Poecilia reticulata Peters, 1859										X	X						X	X		X	
PERCIFORMES																					
Cichlidae																					
Aequidens tetramerus (Heckel, 1840)																				X	
Cichlasoma amazonarum Kullander, 1983	X				X									X							X
Crenicichla labrina (Spix and Agassiz, 1831)					X																
Retroculus lapidifer (Castelnau, 1855)							X											X			

ACKNOWLEDGMENTS: We are indebted to Edson Santana and Lucas Jarduli (UEL) for helping in the collection of fishes; to Fernando C. Jerep (USNM) for identification of species of cheirodontine and manuscript evaluation; to Flávio Lima (UNICAMP) for identification of species of characiforms; to Lilian Casatti (IBILCE/UNESP) for manuscript suggestions; to Universidade Estadual de Londrina for providing the logistic support; to Fundação Araucária for financial support (14/2008, protocol 14834) and student fellowship to ACG; OAS is granted by CNP (proc. 308624/2009-2).

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Appendix 1. Voucher specimens from the upper rio Tocantins basin, Goiás State, Brazil.

Parodontidae: *Apareiodon machrisi* (MZUEL 5833, 5916, 5926, 5943, 5948, 5956, 5963, 5997, 6004, 6022, 6417). **Curimatidae:** *Cyphocharax spilurus* (MZUEL 5864); *Cyphocharax* cf. *vanderi* (5929); *Steindachnerina amazônica* (MZUEL 5790, 5893, 6420). **Anostomidae:** *Hypomasticus megalepis* (MZUEL 5962, 5981); *Leporinus friderici* (MZUEL 5874, 5908). **Crenuchidae:** *Characidium gomesi* (MZUEL 5940) *Characidium* sp. 1 (MZUEL 5973); *Characidium* sp. 2 (MZUEL 5971); *Characidium* cf. *xanthopterum* (MZUEL 5792, 5839, 5930); *Characidium zebra* (MZUEL 5796, 5797, 5814, 5831, 5842, 5868, 5887, 5902, 5913, 5922, 5942, 5949, 5955, 5969, 5986, 6014, 6029). **Characidae:** *Astyanax* cf. *bimaculatus* (MZUEL 5800, 5806, 5807, 5825, 5889, 5928, 6419); *Astyanax elachylepis* (MZUEL 5802, 5873, 6027); *Astyanax* sp. gr. *scabripinnis* (MZUEL 5886), *Astyanax* sp. (MZUEL 5804, 5988, 6018 5822); *Brycon nattereri* (MZUEL 5745); *Bryconops caudomaculatus* (MZUEL 5823, 5900, 5917, 5970), *Caiapobrycon tucurui* (5793, 5974); *Compsura* sp. (5841); *Creagrutus atrisignum* (MZUEL 5835, 5918, 5921, 5927, 5995); *Creagrutus britskii* (MZUEL 5832, 5819, 5966, 6003); *Ctenobrycon spilurus* (MZUEL 5843, 5898); *Galeocharax gulo* (MZUEL 6000); *Jupiaba apenima* (MZUEL 5788, 5886, 5936, 6031); *Knodus* cf. *chapadae* (MZUEL 5805, 5824, 5840, 5851, 5881, 5892, 5914, 5924, 5945, 5958, 5994, 6015); *Knodus* sp. 1 (MZUEL 5841, 5879, 5899, 5959, 6023); *Knodus* sp. 2 (MZUEL 5794, 5903, 5905, 5910, 5935, 5947, 5967, 5990, 5999); *Moenkhausia grandisquamis* (MZUEL 5911); *Moenkhausia aurantia* (MZUEL 5801, 5803, 5891, 5895, 5912, 5923, 6016); *Mylesinus paucisquamatus* (MZUEL 5867, 6008); *Myloplus* sp. (MZUEL 5863); *Phenacogaster* sp. (MZUEL 5854); *Ctenocheirodon pristis* (MZUEL 6019); *Serrapinnus* sp. (MZUEL 5808, 5838, 5844). **Acestrorhynchidae:** *Acestrorhynchus falcatus,* (MZUEL 5869, 5979). **Erythrinidae:** *Hoplias malabaricus* (MZUEL 5798, 5829, 5852). **Cetopsidae:** *Cetopsis arcana* (MZUEL 5850, 5976); **Callichthyidae:** *Aspidoras eurycephalus* (MZUEL 5992). **Trychomycteridae:** *Paravandellia* sp. (MZUEL 6007). **Loricariidae:** *Ancistrus* sp. (MZUEL 5810, 5818, 5938, 5946, 5954, 5984, 6009, 6021); *Corumbataia* cf. *tocantinensis* (MZUEL 5802, 5890, 5920, 5951, 5996); *Harttia punctata* (MZUEL 5870, 5906, 5933, 5957, 5965, 5989, 6001, 6025); *Hypostomus* sp. 1 (MZUEL 5872), *Hypostomus* sp. 2 (MZUEL 5837, 5875); *Hypostomus* sp. 3 (MZUEL 5830); *Hypostomus* sp. 4 (MZUEL 5789, 5799, 5845, 5877, 5878, 6415, 5885, 5907, 5845, 5950, 5961, 5972, 6013, 6024); *Hypostomus* sp. 5 (MZUEL 5791, 5809, 5862, 6028, 5836); *Parotocinclus* sp. (MZUEL 5834, 5882); *Rineloricaria* sp. (MZUEL 5883, 5894, 5919, 5931, 5939, 5952, 5964, 5987, 6010, 6032); *Spatuloricaria* cf. *evansii* (MZUEL 5871, 5909, 5982, 6030); *Squaliforma emarginata (*MZUEL 5876*).* **Pseudopimelodidae:** *Microglanis* sp. n. (MZUEL 5925); *Pseudopimelodus pulcher* (MZUEL 6039). **Heptapteridae:** *Cetopsorhamdia molinae* (MZUEL 5904, 5980); *Phenacorhamdia* sp. (MZUEL 5795, 5811, 5880, 5896, 5901, 5915, 5941, 5991, 5998, 6026); *Pimelodella* sp. (MZUEL 5884, 5934, 5975, 5993, 6002); *Rhamdia quelen* (MZUEL 5937, 5953). **Gymnotidae:** *Gymnotus* sp. (MZUEL 5815, 5848). **Sternopygidae:** *Eigenmannia trilineata* (MZUEL 5846, 5853, 6012); *Sternopygus macrurus* (MZUEL 5856). **Apteronotidae:** *Apteronotus camposdapazi* (MZUEL 5847); *Apteronotus* sp. (6416). **Poecillidae:** *Poecilia reticulata* (MZUEL 5888, 5897, 5960, 5978, 6017). **Cichlidae:** *Aequidens tetramerus* (MZUEL 6011); *Cichlasoma amazonarum* (MZUEL 5813, 5855, 5932, 6020); *Crenicichla labrina* (MZUEL 6421); *Retroculus lapidifer* (MZUEL 5865, 5968).

RECEIVED: September 2012
ACCEPTED: November 2012
PUBLISHED ONLINE: February 2013
EDITORIAL RESPONSIBILITY: Tiago Pinto Carvalho